Oct. 16, 1962 J. M. MORRIS ET AL 3,058,235

VIBRATORY HEAT TRANSFER APPARATUS

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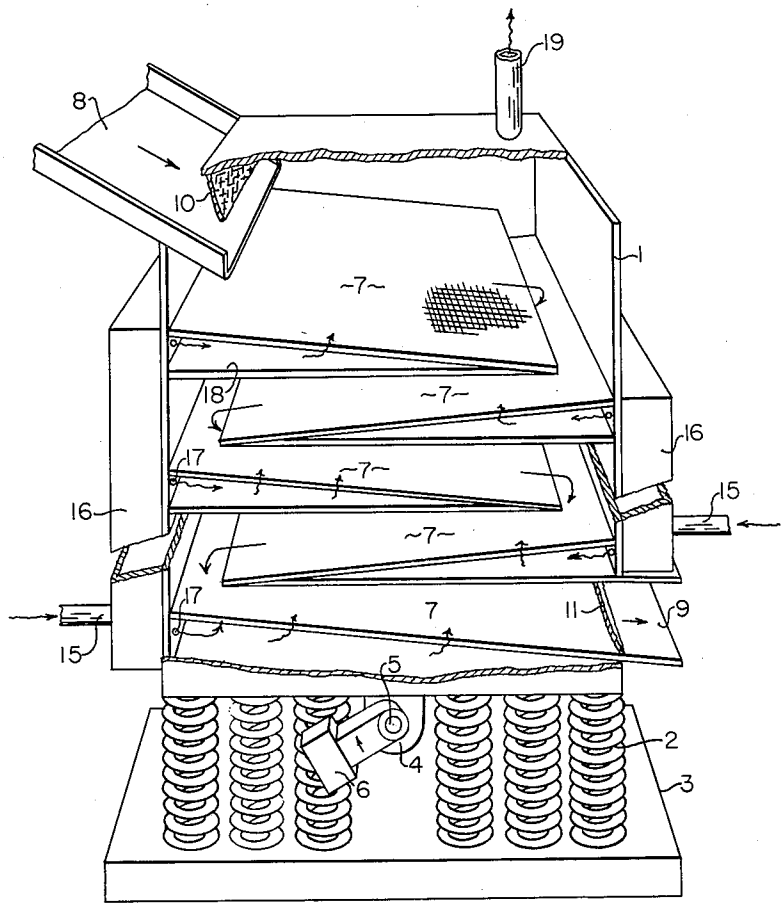


Fig. 1

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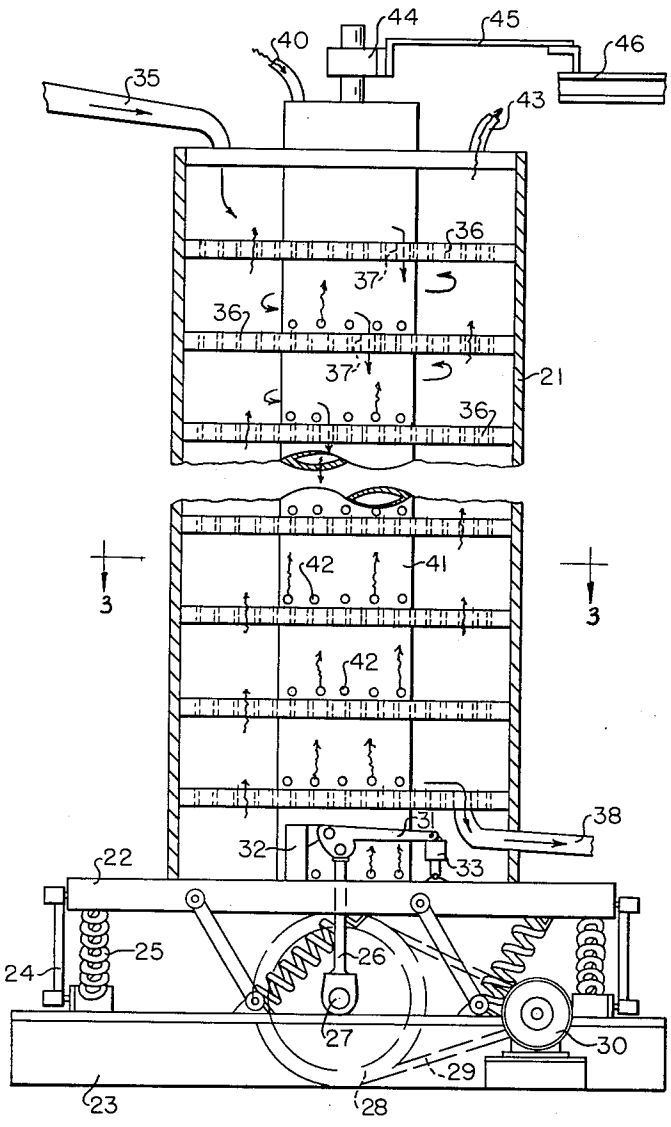


Fig. II

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VIBRATORY HEAT TRANSFER APPARATUS

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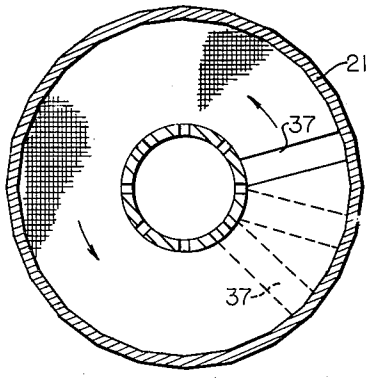


Fig. III

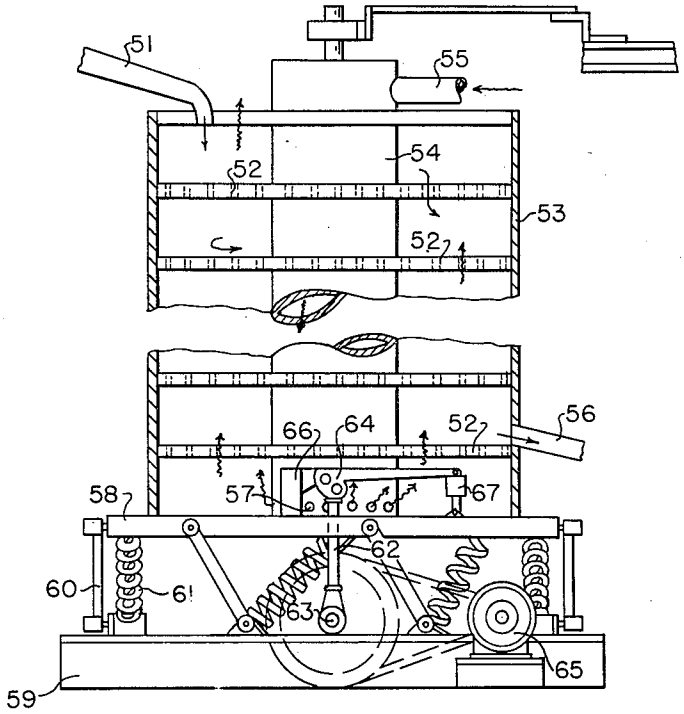


Fig. IV

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VIBRATORY HEAT TRANSFER APPARATUS

Filed July 26, 1957 6 Sheets-Sheet 4

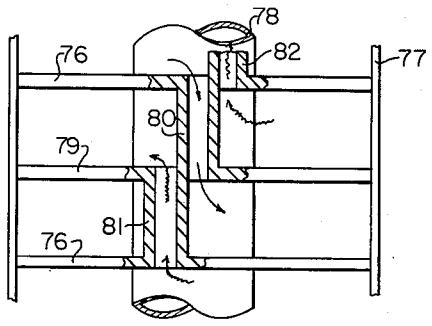


Fig. V

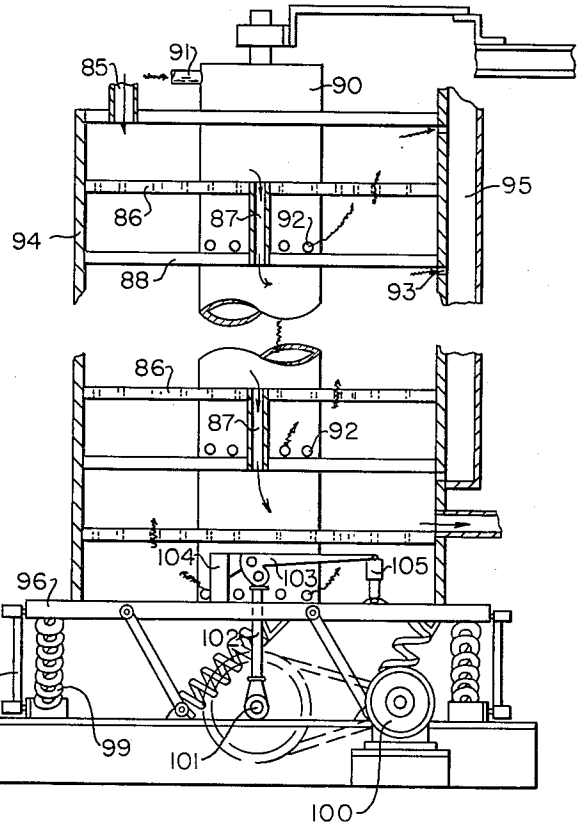


Fig. VI

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VIBRATORY HEAT TRANSFER APPARATUS

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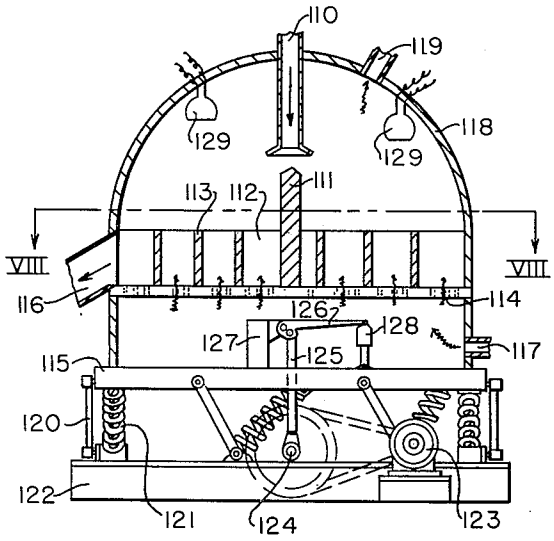


Fig. VII

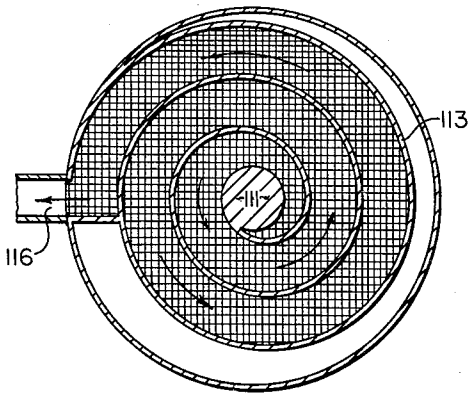


Fig. VIII

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VIBRATORY HEAT TRANSFER APPARATUS

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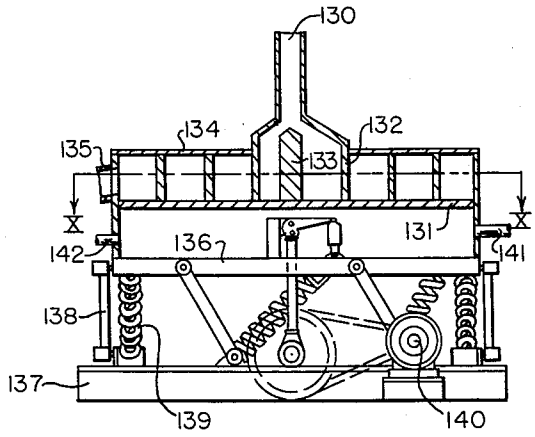


Fig. IX

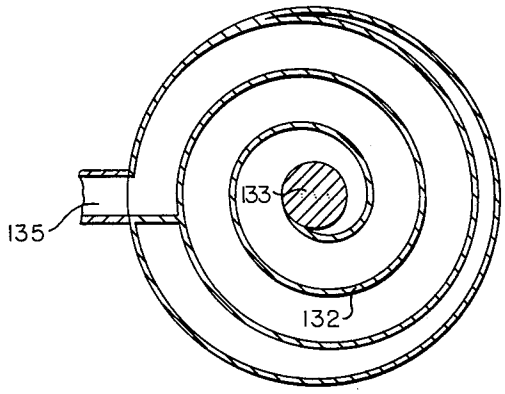


Fig. X

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United States Patent Office 3,058,235 Patented Oct. 16, 1962

3,058,235

VIBRATORY HEAT TRANSFER APPARATUS

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Filed July 26, 1957, Ser. No. 674,366
5 Claims. (Cl. 34—164)

This invention relates to heat transfer units employing vibration to enhance the rate of heat transfer between a treating medium and the material being treated and in particular to improved arrangements of the structure to incorporate a large amount of material contacting surface in a relatively small volume.

Vibrating conveyors both helical and straight line have been adapted for use as heat transfer units by either heating the deck of the conveyor or enclosing the conveyor and passing a treating medium through the enclosure along with the material to be treated. Such adaptations have not been entirely satisfactory because of the difficulty of accurately controlling the retention time, i.e., the rate of flow through the device, or because they occupy an excessive amount of floor space in the shop for the actual amount of treating area available in the device.

The principal object of this invention is to provide a vibrating heat transfer unit that incorporates a great amount of material treating surface in a relatively small compact assembly that may be vibrated at controlled amplitudes to provide suitable retention time for the material passing through the treating zone.

Another object of the invention is to provide a compact sturdy vibrating heat transfer unit that may be built in large sizes without subjecting any of its parts to abnormally high stresses which would lead to early failure.

Another object of the invention is to provide a vibrating heat transfer unit so arranged that the feeding movement of material through the structure is small compared to its amplitude of vibration.

A still further object of the invention is to provide a vibrating heat transfer unit in which the material being treated follows a tortuous path that is long compared to the longest dimension of the unit.

These and more specific objects and advantages are obtained in vibrating heat transfer units constructed according to the invention.

According to the invention the vibrating heat transfer units are constructed so that the material follows a tortuous path, in either a vertical or horizontal direction or both, that is long compared to the dimensions of the frame and casing enclosing the unit. The frame is mounted on resilient means so that it may be vibrated at substantial amplitudes to provide both agitation of the material to enhance the heat transfer characteristics as well as to cause the material to progress at controlled rates along the tortuous path from the inlet to the outlet of the heat transfer unit. Preferably, but not necessarily, the resilient supporting means for the frame of the heat transfer unit is selected in accordance with the operating speed of the unit so that it vibrates at its reasonant frequency. The actual construction of the vibrating heat transfer unit may take various forms depending upon the treating mediums to be employed, the characteristics of the material being treated, and by the type of heat transfer to be employed, that is whether the treating medium shall come in direct contact with the material or whether the heat shall be transferred by conduction through the vibrating decks or trays of the heat transfer unit.

Preferred forms of the invention are illustrated in the accompanying drawings.

In the drawings:

FIG. I is a perspective view, partly in section, showing one form of heat transfer unit in which the material flows back and forth across a series of interleaved trays mounted in a vibrating frame.

FIG. II shows another form of the invention in which a plurality of superposed, generally annular trays are arranged in a vibrating frame such that the material flows around each tray and then drops through a slot in the tray to the next lower tray.

FIG. III is a horizontal section taken substantially along the line III—III of FIG. II.

FIG. IV is an elevation, partly in section, of a heat transfer unit substantially as shown in FIG. II except for the path of the treating medium through the transfer unit.

FIG. V is a fragmentary vertical section showing an arrangement of the successive decks or trays of a circular heat transfer unit wherein the material and the heating medium do not come into direct contact with each other.

FIG. VI is an elevation, partly in section, of another form of superposed circular tray type of heat transfer unit showing an arrangement for intermingling the material being treated and the heat transfer medium.

FIG. VII is an elevation, partly in section, of a heat transfer unit in which the material flows in a horizontal spiral path from the inlet to the outlet of the unit while it is being subjected to the treating medium.

FIG. VIII is a horizontal section taken substantially along the line VIII—VIII of FIG. VII.

FIG. IX is an elevation, partly in section, of another form of spiral heat transfer unit in which the treating medium acts indirectly on the material being treated.

FIG. X is a horizontal section taken substantially along the line X—X of FIG. IX.

These specific figures and the accompanying description are intended merely to illustrate the invention and not to impose limitations on its scope.

Many industrial processes require that heat be added or extracted from a material being processed at relatively rapid rates. Some such processes require that the material being treated be kept in a neutral or non-oxidizing atmosphere during such treatment while others require that the material be subjected to reagents during such treatment. The material to be treated may be a finely divided powder, a granular material, in fact, any material that can be conveyed by a vibratory conveyor. All of these may be encompassed by the term "bulk" materials. When the material is in the form of a finely divided solid, such as a powder, it is difficult to get high rates of heat transfer through the material because of the insulating nature of most powdery materials. It is therefore necessary in such situations to employ vibration to keep the material agitated and in motion so that all parts of the charge of material are brought into contact with the heat transfer surfaces or into contact with the heat transfer medium itself.

The heat transfer medium in general is a fluid, either liquid or gaseous, that is brought into intimate contact with the material itself for direct transfer or with the trays on which the material is carried for indirect transfer of heat. If the heat transfer material is not to come into direct contact it may be passed through duct-like spaces beneath and in contact with the trays or vibrating surfaces on which the material is carried.

When the heat treating medium is to be brought into intimate contact with the material being processed it may conveniently be supplied through porous trays so as to flow upwardly through the vibrating material. Alternatively, if the medium is gaseous or considerably lighter or of lesser density than the material being treated

so as to be easily separated, it may be introduced at the discharge end of the vibrating heat transfer unit and caused to flow counter to the material flow through the unit and out of the top of the unit. These methods are particularly useful when the heat treating medium is gaseous but may also be used in some cases with a liquid treating medium.

In a first form of the invention, as illustrated in FIG. I, a box-like frame **1** is supported on a plurality of coil springs **2** erected from a base **3**. The frame **1** on its lower central portion carries a pair of bearings **4** that journal a rotating shaft **5** carrying eccentric weights **6** that apply vibratory force to the frame **1** and cause it to vibrate on its resilient support as provided by the coil springs **2**. A plurality of gently sloping pervious trays **7** are mounted within the box-like frame **1** so that material to be treated, that is introduced through a chute **8**, may flow, as indicated by the arrows, across each tray and drop off its lower edge to the next lower tray and then travel back across the width of the box-like frame **1** until it drops off of that tray onto the next lower tray and finally is discharged from the lowermost tray through a discharge opening **9**. This back and forth path of travel constitutes a tortuous path in a vertical direction.

To prevent the free escape of the treating medium used within the frame, a flexible curtain **10** may be used to close the chute **8** except as it is pushed aside by the incoming material to be treated. Likewise a second curtain **11** hung across the discharge opening **9** may limit the escape of treating gas from the lower end of the equipment. If the pressures are too great for curtains, star feeders or similar closed feeders may be used.

While a system such as the frame **1** supported on the coil springs **2** has several degrees of freedom, that is it may vibrate in several different modes, the springs are selected and distributed and the operating frequency adjusted so that the frame **1** vibrates principally in a vertical direction with only a small lateral motion that is symmetrical about a vertical axis. Thus the vibration may agitate the material and more or less fluidize it so that it flows evenly down the gently sloping trays in whichever direction they are sloped. While, for convenience in illustration, the axis of the rotating shaft **5** is shown as extending transversely to the path of the material over the trays, it preferably is located generally parallel to the path of movement of the material across the trays so that any unbalanced horizontal motion of the trays will not tend to increase or decrease the flow of material down each tray.

The treating medium, preferably in gaseous form, flows, as indicated by the wavy arrows, through ducts **15** into manifolds **16** located on each side of the box-like frame **1** and thence through ports **17** into the spaces directly beneath the porous trays **7** that are enclosed on the sides and bottoms by impervious pans **18** attached to the sides of the box-like frame **1** or fit closely under the trays **7**. The treating medium, after passing through the pervious trays **7** and the material carried thereon, passes upwardly between the trays counter to the flow of material and is finally exhausted through an exhaust duct **19**.

One particular advantage of this type of compact heat transfer unit is the direct transfer of stress through the frame to the springs so that the system may operate at fairly large amplitudes of vibration as may be required to agitate the material without inducing large stresses in the box-like frame **1** or the springs **2**. This result is obtained by operating the system at its natural frequency and distributing the springs supporting the box-like frame **1** to provide an evenly distributed support rather than concentrating the support over a few springs.

Another form of the invention is illustrated in FIG. II. In this example a box-like enclosed frame **21** in the form of a multi-sided prism which may approach a circular form as the number of sides is increased is erected from a subbase **22** that is resiliently supported from a main base **23** by a combination of inclined links **24** and helical springs **25**. The links **24** and the springs **25** are arranged around the periphery of the generally circular subbase **22** and main base **23** so that the subbase **22** may execute a short helical motion, pivoting on the links **24**, while the springs **25** are extended or compressed. Vibratory force is applied from the main base **23** to the subbase **22** through a connecting rod **26** carried on a crank shaft **27** that, through pulleys **28** and belt **29**, is driven by a drive motor **30**. The upper end of the connecting rod **26** is connected to the subbase **22** through a lever **31** one end of which is pivotally mounted on a rigid support **32** erected from the subbase **22** and the other end of which is connected through a shock absorber **33** to the subbase **22**. The shock absorber permits the subbase **22** to rise or fall with changes in load on the subbase without imposing corresponding loads on the connecting rod **26**. The connecting rod and lever system may be duplicated at each side of the subbase **22** so as to apply vertically directed vibrating forces symmetrically to the subbase **22**.

The material to be treated is introduced into the frame **21** through a chute **35** so that it drops onto the upper one of a series of trays **36** contained within the multi-sided enclosed frame **21**. The trays **36** are horizontal annular conveying surfaces and the helical vibration imparted through the subbase **22** and the frame **21** to the trays **36** causes the material to flow, as indicated by the arrows, around each tray until it drops through a slot **37** in the tray (FIG. III) onto the next tray below and finally is discharged through a chute **38**.

The treating medium is introduced through an inlet duct **40** into a cylindrical manifold **41** extending axially of the enclosed frame **21**. The trays **36** each encircle the manifold **41** which in effect forms the inner wall of each tray. The treating medium is discharged from the manifold **41** through a series of ports **42**, some of which are located just above each of the trays, and flows upwardly (as indicated by the wavy arrows) through the porous trays **36** and the slots **37** until it is finally discharged from the top of the frame **21** through an exit duct **43**. The trays **36** are preferably made porous, such as a fine screen, fine enough to convey the material and yet coarse enough to allow the treating medium to pass upwardly through the trays and the material being treated thereon. The vibration keeps the material agitated so that the treating medium can flow freely through the conveyed bed of material and thus contact all the particles of the material.

In some instances, the height of the cylindrical or multi-sided frame **21** may be large compared to the area of the base **23** or subbase **22** so that it is desirable to provide a lateral support at the upper end. In FIG. II this is illustrated as comprising a bearing or clamp **44** attached to the upper end of the cylindrical manifold **41** and connected through a resilient strut **45** to a beam **46** forming part of the building structure or other framework surrounding the equipment. If the member **44** is a clamp rigidly attached to the manifold **41** it is necessary that the resilient strut **45** have sufficient elasticity in bending to accommodate the rotary motion as well as the vertical component of the helical vibration imparted to the frame.

In the arrangement shown in FIG. II, the treating medium is applied fresh to each tray of material and the spent medium passes upwardly through the trays above and is finally exhausted. If it is not necessary to apply fresh medium to each tray, an arrangement similar to that shown in FIG. IV may be substituted for that shown in FIG. II. In the arrangement shown in FIG. IV, the material to be treated is admitted through an inlet chute **51** from which it drops onto an uppermost porous tray **52** that is carried in a generally cylindrical or multi-sided enclosure frame **53** surrounding a central cylindrical tube **54** serving as an inlet manifold for a treating me-

dium supplied through an inlet pipe 55. The material after passing around the tray 52 drops through a slot, similar to the slot 37, onto the next lower one of the trays 52 and so on down tray by tray until it is finally discharged from the lowest one of the trays 52 through an outlet or discharge chute 56.

The treating medium which is supplied through the inlet pipe 55 and the cylindrical manifold 54 is discharged through ports 57 at the lower end of the manifold 54 and from thence it rises through the porous trays 52 and material being carried thereon and is finally discharged through the upper end of the cylindrical frame 53.

The generally cylindrical frame 53 is carried on a subbase 58 which in turn is supported from a main base 59 by a plurality of inclined struts 60 and compression springs 61. The struts 60 and springs 61 are inclined so that vertically applied vibrational force transmitted through a connecting link 62 from a crank shaft 63 to a transmission lever 64 mounted on the subbase 58 causes the subbase 58 and the cylindrical frame 53 mounted thereon to vibrate along a short helical path. Similarly to the structure shown in FIG. II, the crank shaft 63 is belt connected to a motor 65. The transmission lever 64 has one end pivoted to a bracket 66 erected from the subbase 58 and has its other end connected through a shock absorber 67 to the subbase 58. The shock absorber 67 permits the subbase 58 to rise and fall on the springs 61 as may be required by changes in active load on the trays 52 without producing a corresponding stress in the connecting rod 62.

In both of these arrangements as shown in FIGS. II and IV the treating medium comes in direct contact with material being treated. The system shown in FIG. II provides fresh treating medium to each tray while that shown in FIG. IV supplies the treating medium at the bottom of the stack of trays and allows the treating medium to flow upwardly through all of the trays. If the material is being heated by the treating medium this provides the advantage that the hottest portion of medium is applied to the warmed or heated material on the bottom tray and as the medium flows upwardly and loses its heat to the material it meets colder and colder material thereby maintaining a nearly constant temperature differential between the material and the medium. This is of advantage in some instances or some processes in which it is undesirable to have too great a temperature difference between the treating medium and the material such as might cause thermal shock or other ill effects. The system shown in FIG. II in contrast supplies fresh treating medium to each of the series of trays and is thus adapted to chemical processes in which the treating medium actually is a reagent that reacts with the material being treated.

In some processes it is undesirable to mix or allow direct contact between the treating medium and the material being processed. The structure illustrated generally in FIGS. II and IV may be modified to provide indirect heat transfer by making the trays imperforate and causing the material to drop through chutes from one tray to the next but one tray below. The treating medium is channeled to flow through the spaces between those trays carrying the material and the trays immediately there beneath. Such arrangements are illustrated in FIGS. V and VI.

In the arrangement shown in FIG. V, showing a fragment only of a system generally similar to that shown in FIGS. II or IV, two of the material supporting trays 76 are shown supported in a generally cylindrical frame or housing 77 surrounding a manifold 78. The trays 76 are imperforate and another tray or partition 79 is located therebetween. Material flowing around on the upper one of the trays 76 drops through a chute 80 to the space beneath the tray 79 and above the next lower imperforate tray 76. The chute 80 preferably extends

radially from the manifold 78 to the frame or housing 77 and thus forms a partition to prevent continuous circulation around the manifold in the space between the trays. The treating medium, which is introduced into the bottom of the stack of trays, flows upwardly through a chute 81 connecting the space beneath the lower of the trays 76 and the space between the upper tray 76 and the dividing partition or intermediate tray 79. The medium after flowing around the channel provided in this space escapes to the next higher channel through a chute 82 passing upwardly through the upper tray 76 to the next higher of the dividing trays 79. The vibratory motion imparted to the system of trays causes the material to flow substantially all the way around each one of the trays from one chute 80 to the next. The chutes are staggered so that while each chute provides a passage from one treating space to the next it also forms a partition preventing continuous circulation on one tray. As far as granular or powdered material is concerned the partitions are not essential but when a fluid treating medium is employed the partitions are needed to force the fluid to flow in the proper direction and contact all portions of the trays rather than flowing from the chute 81 to the next chute 82.

In this type of construction, providing indirect heat transfer, the heating or cooling treating medium may be either liquid or gaseous since its path of travel through the stacked trays is positively defined.

In the next arrangement as shown in FIG. VI, the path of the treating medium is arranged so that any particular portion of the medium after passing through one of the porous trays is immediately exhausted from the system instead of being allowed to flow upwardly through all of the trays above. In this particular arrangement the material to be treated enters by an inlet chute 85, drops onto an uppermost of a series of porous decks 86 and after flowing around such deck drops through a chute 87 to the next lower one of the porous decks 86. Imperforate trays or decks 88 are interposed between the porous decks 86 and, in cooperation with the next above porous deck, form a passage for the treating medium which, having entered a tubular cylindrical manifold 90 by way of an inlet duct 91, flows from the manifold 90 through ports 92 communicating with the spaces between each of the impervious trays 88 and the next higher pervious tray. After passing through the pervious trays and the material carried thereon, the treating medium is exhausted through ports 93 in the side wall of a casing 94 enclosing the system of trays or decks. The ports 93 communicate with an exhaust manifold 95 from which the treating medium may be exhausted to atmosphere or returned to the inlet pipe 91 after being heated, cooled or otherwise reconditioned for further use. The casing 94 containing the trays 86 and 88 is carried on a subbase 96 which in turn is supported from a main base 97 by a plurality of inclined links 98 and compression springs 99. The links and springs are inclined so that vertically directed vibratory forces applied to the subbase 96 will cause it to vibrate along a short helical path that provides conveying action for the material on the trays. The vibratory force is provided by a drive motor 100 that is belt connected to a crank shaft 101 that drives a connecting rod 102 connected to a lever 103. The lever 103 has a first end mounted in a fixed bracket 104 erected from the subbase 96 and has its other end connected through a shock absorber 105 to the subbase 96. This arrangement, similar to that shown in FIGS. II and IV, provides a vibratory force transmission path to the subbase 96 that is yieldable to accommodate rise and fall of the subbase with changes in load on the trays.

In the foregoing examples, the tortuous path for the material had at least a vertical component in addition to its horizontal components. In the next example a tray forming the treating surface is provided with guides such that the tortuous path is confined to a single tray and

follows a spiral path from the one portion of the tray to another. Such an arrangement is illustrated in FIGS. VII, VIII, IX and X.

In the structure shown in FIG. VII material to be treated is introduced through an inlet chute **110** from which it drops onto a divider post **111** and into the inner convolution **112** of a spiral guide **113**. The spiral guide **113** is mounted on a porous deck **114** that is in turn carried on and spaced from a vibrating subbase **115** that vibrates along a short helical path so that the material falling into the inner convolution of the spiral guide **113** after following around the various coils of the spiral is finally discharged through a discharge chute **116**.

The treating medium, either gaseous or liquid, is introduced through an inlet pipe **117** into the space beneath the deck **114** and, after passing upwardly through the porous deck or tray **114** and the material thereon, is collected in a covering hood **118** and exhausted through an exhaust duct **119**. The same type of vibratory structure is used for the support of the porous tray **114** and subbase **115** as was shown in FIGS. II and IV. This comprises inclined links **120** and coil springs **121** that provide the resilient support for carrying the subbase **115** on a main base **122** and permitting it to vibrate along a short helical path. The vibration is produced from a drive motor **123** that is belt connected to a crank shaft **124** which in turn is connected through a connecting rod **125** to a lever **126** that is pivoted in a bracket **127** fixed to the subbase **115** and is yieldably connected through a shock absorber **128** to the subbase **115**. The shock absorber, as mentioned previously, permits the subbase to rise and fall with changes in load on the deck **114**. If the material being passed through the equipment is to be heated, infra-red lamps **129** may be included in the hood **118** to irradiate the material on the tray **114** as it follows the spiral path from the inlet to the outlet.

While the structure shown in FIGS. VII and VIII is suitable for direct contact between a treating medium and the material being treated the structure may be modified to provide for indirect heat transfer as indicated in FIGS. IX and X. In the structure shown in FIGS. IX and X the material to be treated is introduced through an inlet chute **130** where it drops onto an imperforate deck or tray **131** that is provided with a spiral guide **132** and a central distributing post **133**. A cover **134** fitting down onto the top of the guide **132** cooperates with the guide and the tray **131** to define a spiral channel or path for the material. After passing around the several convolutions of the spiral the material is discharged through a chute **135**. The assembly of the tray **131** and guide **132** is carried on and spaced from a subbase **136** that is supported from a main base **137** by inclined links **138** and springs **139**. As in the previous examples, vibration is provided by a drive motor **140** connected through a crank, connecting rod and link to the subbase **136**. Treating medium for heating or cooling the tray **131** is admitted through an inlet pipe **141** and after heating or cooling the tray **131**, as required, is exhausted through an outlet pipe **142** and is either discharged to the atmosphere or is conditioned for recirculation.

In all of the embodiments of the invention previously described, the material to be treated, which in general is a bulk material of either a powdery, granular or lumpy nature, is caused, by vibration and suitable guides, to follow a tortuous path through the equipment which path is long, at least twice as long as any linear dimension of the assembly, compared to the size of the frame or trays comprising the equipment. This provides a maximum of treating area in a given volume and occupies a minimum of floor space in the plant or factory.

While vibration generating equipment that has found acceptance commercially has been illustrated in the drawings other types of vibratory equipment may be substituted as long as the type of vibration is such that it causes the material to feed along the tortuous path through the equipment. The type of vibration may vary from a substantially vertical movement that produces a comparatively large amount of agitation in the material in comparison with its conveying motion to a vibration that produces principally a conveying action. The type of vibration may be selected depending upon the degree of agitation required in the material.

The mass of the system and the resiliency of the supporting springs and the speed of operation may be adjusted, if desired, so that the system operates in a resonant condition and thus requires a minimum of force to maintain a given amplitude of vibration. Conversely, if a very definite amplitude of vibration is desired it may be desirable to operate at other than resonant frequency so that variation in load, the amount of material in the system, will not affect or alter the amplitude of the vibration.

The equipment is suitable for use with various types of treating medium which may be either gaseous or liquid, depending upon the material being handled, and may either come into direct contact with the material or be limited to indirect heat transfer, the selection again depending upon the characteristics of the materials and the treating medium.

Various modifications may be made in the specific design and construction of the heat transfer equipment without losing the advantage of economy of space achieved by causing the material to follow a long tortuous path through a compact assembly of trays and guides.

Having described the invention, we claim:

1. In an apparatus for treating bulk materials, in combination, a frame having impervious side walls and bottom, a plurality of horizontal generally circular porous tray portions mounted in the frame in position to feed from one tray position to the next, each tray having a spill slot to feed material to the next lower tray, resilient means for mounting the frame and forming with the frame a vibratory system adapted to vibrate along a path inclined to the tray portions, means for applying vibratory force to the frame to produce vibration along the path, a manifold serving a plurality of tray portion pans, and means for passing a conditioning fluid from the manifold into the space beneath at least one of the trays for movement through the porous trays and the material thereon.

2. In an apparatus for treating bulk materials, in combination, a base, a generally prismatic shell including a solid bottom and a vented top, a plurality of springs supporting the shell and forming with the shell a vibratory system, a plurality of superposed porous trays supported by the shell and forming horizontal partitions in the shell, each tray having a spill slot for discharging material onto the next lower tray, said springs being directed such that said shell vibrates along a helical path for feeding material around said trays, means for applying a vibratory force to the shell at an amplitude to move material around said trays, means for feeding material onto an upper tray, means for receiving material from a lower tray, and means for introducing a fluid below a lower one of said trays in the shell for passage upwardly through the porous trays to the vented top of the shell.

3. In an apparatus for treating bulk materials, in combination, a base, a generally prismatic shell having a solid bottom and a vented top, a plurality of springs supporting the shell from the base for vibration along a generally helical path, a plurality of porous trays supported by the shell and arranged in superposed arrangement in the shell, each of said trays having a spill slot for discharging material to the next lower tray, a central tube perforated at its lower end extending axially of the shell through the trays, means for admitting fluid into the perforated tube for flow from the tube through the porous trays and material thereon, means for feed-

ing material onto an upper one of the trays, means for receiving material from a lower tray, and means for applying vibratory force to the shell at an amplitude sufficient to produce traveling movement of the material on the trays.

4. In an apparatus for treating bulk materials, in combination, a base, a generally prismatic shell having a solid bottom and a vented top, a plurality of springs supporting the shell from the base for vibration along a generally helical path, a center tube passing axially through the shell, a plurality of porous trays mounted in superposed relation in the shell, means for introducing fluid from the center tube into the spaces below the porous trays for passage upwardly through the trays, means for introducing material onto an upper porous tray, means for receiving material fro a lower porous tray, each of the porous trays having a spill slot such that each tray discharges to the next lower tray, and means for applying a periodic force to the shell at an amplitude to produce vibration of the trays to feed material around said trays.

5. In an apparatus for treating bulk materials, in combination, a base, a generally cylindrical frame having impervious side walls and bottom, a plurality of springs arranged in a circle and each having its line of action inclined to the base for supporting the frame from the base for vibration along a helical path, a plurality of horizontal porous trays mounted in the frame, means for vibrating the frame and trays along the helical path to feed material around the trays, each of said trays having a spill slot for discharging material to the next lower tray, means for introducing conditioning fluid at least into the space below the lowest porous tray, and means for driving the fluid upwardly through the porous trays.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,058,235 October 16, 1962

John M. Morris et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 56, for "or" read -- to --; column 8, line 20, for "medium" read -- mediums --; line 37, for "position" read -- portion --; column 9, line 16, for "fro" read -- from --.

Signed and sealed this 21st day of April 1964.

(SEAL)
Attest:
ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents